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ABSTRACT

Learning does not happen in the minds of passive listeners who record into notebooks the anecdotes and chronological information about the history of science presented during a lecture. Lectures address lower levels of cognitive skills and are, therefore, unable to stimulate the higher level skills of application, analysis, and synthesis. At times, students must be active learners. Writing-to-learn techniques allow students to actively seek meaning and understanding on their own. Informal writing, free from immediate, specific evaluation, encourages students to explore ideas and think about history. Several examples of informal student writings show the advantages, as well as the dimensions of the difficulties, of including the history of science as part of the European history curriculum. The use of inquiry learning has not been effective because students are unable to read and analyze difficult primary sources. Short samples of primary source materials, accompanied by narratives, are the most effective means of encouraging students to grapple with scientific ideas expressed by their originators. Student reactions to such methods are presented. Writing-to-learn and collaborative learning techniques can combine to make students more active learners who are better able to appreciate the history of science and its role in European history. But, professional historians must work to change the ways in which this history is presented in secondary textbooks. They must work closely with secondary teachers to effect the necessary changes and develop appropriate teaching strategies. A seven-item bibliography is included. (GEA)

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"The Value and Difficulties of Teaching the History of Science and Technology in Secondary Schools"
by Henry Steffens, University of Vermont

(103rd Annual Meeting of the American Historical Association, Session 17, "The History of Science and Technology in the European History Curriculum of Secondary Schools, Thursday, December 29, 1989, 9:00-11:30 am.)

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I will concentrate upon the word "TEACHING" in the title of my presentation. Fred Gregory has already spoken of our need to review both our understanding of the nature of science and the nature of the history of science in the light of recent scholarship. His presentation emphasized the recent intellectual tradition which places knowledge within a social context. I would like to take a different approach and open a discussion of the teaching of the history of science, focusing on students, and how students best learn both history and the history of science.

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"ACTIVE" VS. "PASSIVE" LEARNING

For myself, and for my history students, the real issue is "active" vs. "passive" learning. I believe that unless students take an active interest in learning, unless they make their own meaningful context within which to place information, unless they see some personally important reason for thinking about history and paying attention, teaching them is largely a futile effort. Teachers waste both their own time and that of their students by providing information without an intelligible context to passive students. That information is soon forgotten.

James D. Heffernan Jr. has raised a similar point in his September 1987 article in *Perspectives* entitled "Traditional or Inquiry: Why Not Use Both?".(1) He used the term traditional to refer to what we all recognize as a typical classroom situation. "In the traditional class the teacher is the expositor of knowledge and the students are the recipients. The major task is transmitting finished knowledge from source to recipient. Whether one uses lectures, discussions, reports or study questions, the idea is to transmit knowledge. Traditional teaching is expository. Its intent is to inform the students of an organized system or some predetermined knowledge." In this traditional mode, the lecture is the teacher's mainstay activity.

We all know that the lecture is the most common form of instruction in history, and in almost every other academic subject for that matter. It is totally teacher directed and aimed at large numbers of students. Students are presumed to learn by listening, and they are not required to do anything but remain quiet and perhaps take lecture notes. They are largely "passive learners". Since attention spans vary up to a maximum of about 15 to 20 minutes, student listeners wander in and out of contact with the lecturer during the course of a 50 minute lecture. If the pace of the lecture is appropriate to the student audience, student listeners may pick up the lecture again after a brief lapse of attention. If the pace is too fast, or the level of presentation too high, the student listeners never really appreciate what is going on during the whole of the

lecture. They may succeed in copying some information from the board or from the overhead projector, or they may copy down some of the lecturer's words into their notebooks. There is little meaning or understanding associated with this activity and therefore little retention. In the worst case, the lecturer does not know what his or her listeners are understanding and assumes that it is the listener's job to make something of the lecture. A recent cartoon in the *American Scientist* (2) illustrates this point quite well:

JOHANNES KEPLER'S UPHILL BATTLE
...SO, YOU SEE, THE ORBIT OF A PLANET IS ELLIPTICAL.
WHAT'S AN ORBIT?
WHAT'S A PLANET?
WHAT'S 'ELLIPTICAL'?
J. Harris

American Scientist, Vol. 76, (Nov.-Dec. 1988), 575

The opening sentence of the introduction to Thomas Kuhn's *The Structure of Scientific Revolutions* (3) comes to my mind whenever I think about pedagorical issues related to the history of science: "History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed." Transformations do not happen in the minds of passive listeners who record into their notebooks the anecdotes and chronological information about the history of science presented to them during a lecture. Lectures are not the appropriate vehicles for presenting complex or abstract materials, nor are they well suited to produce the higher level learning necessary if any transformation in an image of anything is a hoped for result. Lectures address the lower levels of cognitive skills; presenting knowledge or illustrating a point of view or suggesting the intrinsic interest of material. Lectures do not serve well for stimulating or producing the higher level skills of application, analysis, synthesis or influencing attitudes or values. There are a few lecturers who are capable of generating higher level thinking using the vehicle of the lecture alone. They do exist, we generally know who they are, and they are special people. However, if we are seriously concerned with the incorporation of the history of science into the context of European history courses, we need to rely upon more than the lecture. The history of science must be more than anecdote and chronology. For at least part of the time students

need to be active learners. They need to think critically, and they need to write so that they can see what they think, and open a dialogue with themselves over what they are trying to understand. Students need to do more than record and memorize information. They need to actively seek meaning and understanding.

WRITING TO LEARN

The use of writing to learn techniques, a part of writing-across-the-curriculum, offers the opportunity for students to actively seek meaning and understanding on their own. Writing to learn is different from both the more formal writing that we ask our students to do for evaluation, (term papers, reports, and book reviews, for example), and from note taking, in both lecture and reading notes. I usually refer to the kind of writing that students do to help themselves learn as informal writing. Informal writing, free from immediate specific evaluation, encourages students to explore ideas and to think about history. **(4)** It helps them to think as they write, stimulating their imaginations and generating ideas. This kind of writing - informal, expressive, and loosely stuctured - is the form of writing closest to thinking. It allows for the exploration of ideas, for speculations, for the consideration of implications, for the development of ideas in stages of increasing complexity, and for the recall of information from previous experience. Informal writing permits writers to express feelings about a topic, and their degree of commitment to an idea or point of view in a way that more

formal writing does not allow. Through more expressive, infornal writing, students have an oppurtunity to develop ideas, to "see" those ideas for the first time, and to decide whether they disagree or agree with them. As students write in an expressive mode, they often digress to follow an idea, to pursue a connection, or to come to a realization which didn't exist before they wrote. Informal writing helps to explore the connections between ideas and information that is already known. This form of writing may also help in revealing what is not known, or what is only incompletely known. The best writing, and the most valuable in terms of student learning, occurs when the writer is involved in the subject matter. Informal writing is a way of interesting and involving students in the contents of history.

The following examples of informal student writings show the advantages, as well as the dimensions of the difficulties, in including the history of science as part of the European history curriculum. If students are going to learn "yet more stuff" in an already full curriculum, they need to be active learners, and they need to be given many opportunities to write informally for themselves, to help them learn this new subject matter. Fortunately, when students are given the chance to write informally, they clearly understand the advantages to themselves that such writing provides, as well as the changed nature of the learning process which results from such writing. All student samples are reproduced just as they were written:

Entry 3 1/29/86

William Herschel as a "scientist" or natural philosopher.

In his paper on the movements over 23 1/2 years of the double star alpha Geminorium, Herschel exemplifies the characteristics of a scientist. He comes up with a number of proposals to explain the movement of the stars and systematically rejects those that aren't feasible. His reasoning for the rejections is careful and well thought out, showing that he also had some of the chacteristics of a natural philosopher. He would have looked a bit more like a "total " scientist if he had used some mathematical equations and relationships to explain his proposals, but since his background was not mathematical, he substituted painstaking 23 1/2 years of painstaking measurements of the stars to compensate for this lack of mathematical ability.

The fact that he correctly suggested that the diameter between the two stars remained the same because of mutual attraction enforces his stature of a scientist because he came to that conclusion using the scientific method.

#1 My first reaction to this class 1/21/87

I spent my first day in class utterly amazed at how much I couldnt remember from the other science courses I had taken. I couldn't remember simple names like Curie and Joules. These people I should have known since high school - maybe even younger. At this point I became quite

interested in how I could help myself. Granted I am not studing to be a scientist but I do want to have a well rounded education. I feel this course is going to prove to be a great help in this objective. I'm hoping that maybe with the help of the journal I'll remember names and ideas better because I have to write about what I have read.

The last time I did this was for an english class I had. I remember that it takes a short time to get into actually writing, but once you do it becomes easier and easier.

#1 - The Journal

I must admit, keeping a journal for a History class seemed rather strange at first. I was prepared to study by the old routine of text book and class note memorization rather than having my thoughts about a particular subject written in 'black' and white.

But, after pondering the idea for awhile, I realized that keeping a journal of my thoughts on a subject might just help me to sort out and arrange my ideas in some kind of less random fashion. When my ideas are laid out in front of me on a page, it made it easier for me to actually see how my thought patterns worked. It also helps to see what is really most important to me about a subject and what is confusing. The more you write, the more you realize what you are sure of and what seems kind of foggy to you.

I would hope that this journal will help me arrange my thoughts in

this course and to allow me to give a little subjective imput to events that happened well before my birth.

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(1) 9/4 Sunday Reflection on 1st Week

When I signed up for this course, I did it because I didn't want to take another lab science and this could replace it. I never really was any good at history in high school. It always was my worst subject. I never passed the exams or anything. I guess I always found it boring, so whenever I thought about taking this class I got a little sick to my stomache, but anything had to better than another lab science. Now that I have been 2 sessions of the class, I have a totally different view of it. I'm actually kind of interested in it. I think I have realized that history isn't just a lot of memerizing names + dates, which is what I thought it was in high school. History is something more

than that. It will teach me about the progression of mathematics and astronomy and other sciences. I'm a bit more interested in it than I thought I would be. I think the writing in a journal really helps too, because it forces you to really pay attention to what you are reading about. Then, writing about it is just another way of getting more involved that helps you learn the information a lot easier. I'm kind of excited about this course. I must admit that I am a bit nervous, though, considering my past experiences with history classes. I guess I'll just have to try and forget that and take this one step at a time with a better attitude.

"INQUIRY LEARNING"

The terms "inquiry" and "inquiry learning" take on new meanings in the context of students writing to discover what they know and think. "Inquiry teaching" was the heart of the "New History", widely suggested in the 1960's and early 70's. Willis D. Copeland discussed the "New History" in his Feb. 1985 article for *The History Teacher*, "Teaching Students to "Do" History: The Teacher and the Computer in Partnership":

"These proponents of a "New History" intended nothing less than a fundamental reorganization of the history curriculum in the nation's schools. Their vision included training students to follow the examples of professional historians as they "do" history. They advocated an emphasis on the processes and skills of historical investigation rather than memorization of historical facts, substitution of original source material for standard interpretive textbooks, and substantial changes in teacher behaviors. Teachers were to abandon the role of repository of answers and instead help search for them, assuming the role of guide and facilitator of the students' inquiry." **(5)**

The "New History" did not take hold, and seems to have been forgotten in the 80's. I think that the major part of the problem with implementing the "New History" was the use of primary source materials, the actual documents in history and the history of science. It relied upon the student's ability to read critically - and with sustained interest some

very difficult pieces of writing. The majority of students simply didn't have these skills and became mired in unfamiliar vocabulary, forms of expression and concepts. As important as primary sources may be, and as important the skills of reading primary source materials may be to the historian, introductory students can not cope with long, difficult tracts:

#7

9/19 Aristotle text page 61-84

I found the readings for today very difficult. I learned a lot more from discussions by other people on Aristotle. It is very hard to understand and keep reading his passages. It is a lot more useful for me to read about Aristotle then to actually read his writings (Although a sample of his writings is good)

What seems strange to me is that the Atomists said there was never a beginning, the world always existed. How did they feel comfortable saying that?

The question of creation of the beginning of the world has been a question of most importance and awe throughout the centuries, even today people think about how it all began and how it will continue. It seems like a copout to say there is no beginning and no end, just existance.

Short samples of primary source materials, with a narrative to go along with the source, seem to me to be the most effective means of getting students to grapple with scientific ideas expressed by the

originators of the history of science themselves. If visual material can be included as a helpful supplement to the narrative prompt, so much the better. The following student example represents a successful attempt to get students to understand the importance of the English physician William Harvey. Students were assigned brief excerpts from his 1628 treatise "On the Motion of the Heart and Blood in Animals", and also viewed a film which re-enacted some of his actual observations and dissections. Students were asked in class to recall both the readings and the film. Instead of presenting this as a test or quiz, an activity whose primary purpose was evaluation, they were asked to write informally in response to an open-ended question "What was the most important thing about William Harvey?" Having done this before in class, students knew that they were expected to think about the material and come up with a conclusion of their own. There was no one right answer to this question. This student sample shows a student who is likely to remember why William Harvey was important:

#31 11/28

Recall the film + the readings.

What was the most important thing about William Harvey.

I what amazes me is Harvey's completeness. He does experiment after experiment trying to figure out how the blood circulates. The movie backs up this point by showing disections of all types of animals.

It seems that Harvey is not trying to answer all the questions of the universe, like so many before him but he is spending his time trying to understand + theorize how one part of the human body works.

He starts off w/ previous theories + disproves them through experimentation he shows how the heart works and that indeed blood circulates. The big thing was showing what each part of the heart did. And he did this very acurately + meticulously.

To the best of his ability + to the instruements of the time Harvey to a complete experiment + analysis of how the circulatory system worked

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Another major problem for the implementation of the "New History" was summed up in one of the sub-headings to Willis Copeland's article: *Inquiry Teaching is Incompatible with Efficient Classroom Management.* The "New History" was attempted before the role of writing in learning was fully understood, before writing-across-the-curriculum was well begun. I believe that many of the problems associated with "inquiry learning" can now be either alleviated or solved by having students write to learn on their own. The collaborative learning techniques that have recently been emphasized as part of writing-across-the-curriculum will also help to facilitate the use of inquiry teaching, in addition to, and supplementary to, traditional teaching. John Trimbur of Worchester Polytechnical Institute has done a great deal of work with collaborative learning, and describes it as follows:

"Collaborative learning is a generic term, covering a range of techniques that have become increasingly visible in the past ten years, practices such as reader response, peer critiques, small writing groups, joint writing projects, and peer tutoring in writing centers and classrooms.... By shifting initiative and responsibility from the group leader to the members of the group, collaborative learning offers a style of leadership that actively involves the participants in their own learning." **(6)** Whatever the specific techniques used, collaborative learning occurs when students assume some responsibility for the course material, and in the process, help themselves and one another to learn. The collaborative learning approach shifts some responsibility from the teacher to the students; they become active participants in their own education.

I believe that writing to learn and collaborative learning techniques can combine to help make students more active learners, better able to appreciate the history of science and its important role in European history, both in secondary schools and at the college level.

COOPERATION WITH SECONDARY SCHOOL TEACHERS

But, if the history of science and technology are to be included more effectively within the European history curricula of secondary schools, professional historians of science and technology must do more than help to change the ways in which the history of science and technology are contained within the textbooks used at the secondary level. We need to take active roles in developing effective writing to learn

strategies for students in the history of science and technology. We need to think harder about the realistic use of primary source materials as ways of imparting an understanding of the history of science and technology. Even more than this, professional historians of science and technology need to work cooperatively with secondary school teachers. Happily, the situation is not hopeless. Secondary school teachers are ahead of college and university professors in their interest in pedagogy and their awareness of both writing to learn and collaborative learning. So are Community College teachers. Without relating the obvious lack of concern for pedagogy at the so called "upper levels" of our profession, or the institutional and professional reasons for this lack of concern, it is sufficient to say that the road to the effective incorporation of the history of science and technology into European history in secondary schools lies in the direction of cooperation with the secondary school teachers who will be doing the teaching. Without their cooperation, indeed without their guidance and help, any attempt will be, in my opinion, a "non-start". We might as well not think about doing anything, because it won't work.

In the process of giving writing-across-the-curriculum workshops, and in-service programs devoted to writing to learn, and to helping history students learn history better, I have met many history teachers. There are devoted, bright, enthusiastic, knowledgeable teachers in our schools who are ready to cooperate with historians of science and

technology. We need to ask for their cooperation, if we really want to improve the teaching of the history of science and technology at all levels of the European history curriculum.

ENDNOTES:

1. James D. Heffernan, Jr., "Traditional or Inquiry: Why Not Use Both?", *AHA Perspectives,* (Sept., 1987), 12-14.

2. *American Scientist,* Vol. 76, (Nov.-Dec. 1988), 575.

3. Thomas S. Kuhn, *The Structure of Scientific Revolutions,* 2nd edn., (Chicago, 1970), 1.

4. For a more extensive account of the uses of informal writing to help students learn history, see Henry Steffens, "Journals in the Teaching of History", in Toby Fulwiler, *The Journal Book* (Portsmouth, N.H.: Heinemann Educational Books, 1987), 219-226; and Henry J. Steffens and Mary Jane Dickerson, *Writer's Guide: History,* (Lexington, Mass.: D.C. Heath and Co., 1987).

5. Willis D. Copeland, "Teaching Students to "Do" History: The Teacher and the Computer in Partnership", *The History Teacher,* (Vol. 18, No. 2, Feb. 1985), 189-197.

6. John Trimbur, "Collaborative Learning and Teaching Writing," in B.W. McClelland and T.R. Donovan, *Perspectives on Reasearch and Scholarship in Composition,* (New York, 1985), 87-109.